PREDICTIVE ANALYSIS OF TEMPERATURE RELATED CHALLENGES IN BANGLADESH: A MACHINE LEARNING APPROACH FOR ASSESSING THE IMPACT OF RISING TEMPRATURE

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FINAL YEAR DESIGN PROJECT REPORT

This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled "**Predictive Analysis of Temperature-Related Challenges in Bangladesh: A Machine Learning Approach for Assessing the Impact of Rising Temperatures**", submitted by **Md. Mostafizur Rahman** and **Md. Akil Hasan** to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on **14-07-2024**.

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We hereby declare that this project has been done by us under the supervision of **Mohammad Jahangir Alam, Lecturer (Senior Scale), Department of Computer Science and Engineering, Daffodil International University**. We also declare that neither this project nor any part of this project has been submitted elsewhere for the award of any degree or diploma.

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ABSTRACT

We are writing a paper based on the temperature in Bangladesh. Where we are working on a dataset from (2000-2022) that spans 23 years. We collected the data from NASA's website(power data access viewer) [31] to help us build this project. We worked on this dataset from where we used some machine learning algorithms like ARIMA(Autoregressive Integrated Moving Average), ETS(Exponential Smoothing), Prophet, LSTM(Long short-term memory) where we tried to predict the surface temperature in future because of the temperature is increasing day by day and it is rising upwards and thus we tried to measure the temperature to predict how warmer the country of Bangladesh can get. This data collection is preprocessed and done by using machine learning algorithms to try and predict the best possible way of getting correct evaluation of data. Because of this rising temperature, we are trying to overcome the issues that we might encounter where people are facing many temperature related problems and vulnerabilities. And we will also provide some valuable insights from this project to deliver a better outcome to resolve these issues. And we are also hopeful to get a better value that can help us solve these problems by assessing the impact of rising temperatures.

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ML	Machine Learning
ARIMA	Autoregressive Integrated Moving Average
ETS	Exponential Smoothing
Prophet	Prophet Model
LSTM	Long Short Term Memory

CHAPTER 1
Introduction

1.1 Overview

Heat waves pose a significant threat to the people of Bangladesh due to the country's geographical location, climate, and socio-economic factors. High temperatures can lead to heat-related illnesses like heat exhaustion and heatstroke, with vulnerable groups such as the elderly, children, and those with health issues at increased risk. Dehydration is also a concern, especially in areas with limited access to clean drinking water, potentially causing severe health complications. The reliance on agriculture in Bangladesh makes the population vulnerable to heat waves, as drought conditions can damage crops and lead to food shortages and economic struggles for farmers. Additionally, the increased demand for electricity for cooling during hot weather strains the power grid, causing frequent power outages that disrupt daily life and essential services. Water scarcity becomes a problem during heat waves, impacting drinking water supply and sanitation efforts, which raises the risk of waterborne diseases. Outdoor workers, including construction laborers and farmers, face dangers from extreme heat, risking their livelihoods. In rural areas, heat waves and droughts may drive people to migrate to urban areas for better opportunities, putting pressure on urban resources and infrastructure. Climate change exacerbates these challenges by contributing to more severe and frequent heat waves in Bangladesh.

1.2 Background and Present State

We did background studies where we tried to gather information about the weather of Bangladesh and also did some background research on temperature of previous years. The dataset we have, has the data of past 23 years of temperature where we tried using the machine learning algorithm to predict the surface temperature and while doing that we got some results that are discussed further in this research.

1.3 Problem Statement

In light of increasing global temperatures, particularly in regions vulnerable to climate change such as Bangladesh, there is a pressing need to comprehensively evaluate the specific challenges and vulnerabilities arising from rising temperatures. This study aims to address this gap by conducting a detailed case study analysis of temperature-related challenges faced by Bangladesh, focusing on the socio-economic impacts, health risks, and environmental consequences associated with escalating temperatures in the region.

1.4 Objectives

1. Evaluate temperature trends in Bangladesh from 2000 to 2022 using NASA's Power Data Access Viewer dataset.
2. Apply machine learning algorithms including ARIMA model, ETS, Prophet, and LSTM to predict future surface temperatures.
3. Assess the impact of rising temperatures on heat-related illnesses and vulnerabilities in Bangladesh.
4. Analyze the implications of temperature increases on agricultural productivity and food security.
5. Investigate the strain on infrastructure and services due to increased demand for cooling during heat waves.
6. Compare the predictive accuracy of different machine learning models to identify the most effective for temperature forecasting.
7. Provide actionable insights for policymakers to mitigate the socio-economic and health risks associated with rising temperatures.
8. Propose avenues for future research to enhance climate modeling accuracy and broaden the scope of environmental variables considered in temperature predictions.

1.5 Scope and Limitations

Objectives , project related questions ,inclusion and exclusion , methodology , constraints and limitations , expected outcomes are sub sections of project scope . That means what's the boundary or limitations of the project . objectives is the task which will be completed in a project and by completing objectives this project will be able to answer people's questions which will show the limitations of the project .

1.6 Report Organization

1. In chapter 2, we have overview, related work, comparison between existing works(including table), open issue, summary of literature review after reading more than 30 research papers.

2. In chapter 3, we have an overview, proposed methodology/system design, hardware/ software requirement. After that project management and financial analysis and lastly the overall summary.

3. In chapter 4, we have an overview, train model/ prototype design, system testing/ model evaluation, summary of implementation.

4. In chapter 5, we have an overview, Experimental/ Simulation Result, Performance/ Comparative Analysis, summary of result and analysis.

5. In chapter 6, we have an overview, train model/ prototype design, system testing/ model evaluation, summary of impact on society, environment and sustainability.

6. In chapter 7, we have conclusions, further suggested works, Limitations/ Conflict of Interests of conclusion and future work.

1.7 Summary

This paper explores temperature trends in Bangladesh from 2000 to 2022 using NASA data, applying machine learning algorithms like ARIMA, ETS, Prophet, and LSTM to predict future temperatures. Highlighting the risks of heat-related illnesses and agricultural impacts, the study identifies Prophet as the most accurate model with 95.73% accuracy. It emphasizes the role of predictive analytics in climate adaptation and suggests future research directions for improving model effectiveness.

CHAPTER 2
Literature Review

2.1 Overview

We tried to find some literature work which is based on temperature related works that were done before in Bangladesh. We found some good ones as well. We tried to gather as much information as we can get from these papers, in order to increase our knowledge and make sure that the paper we are trying to work on, can be an improvement to the cause.

2.2 Related Works

The majority of studies have concentrated on annual mean temperatures and monthly predictions.Up until now, air temperature forecasts have been made using conventional statistical techniques like cluster analysis and linear regression. These models estimate the probability that a specific weather phenomena will materialize in the future by statistically analyzing historical data. On the other hand, the factors and processes causing changes in air temperature are quite complex and nonlinear. Because dynamic temperature changes are hard to record, long time series of hourly or daily temperature cannot be accurately predicted using statistical approaches. The trend of changing air temperature has been predicted by machine learning approaches such as support vector machines (SVM), Linear Regression , Random Forest Regression etc.

In Paper [1] by Md. Abdullah Al Mamun et al. (2024), key weather parameters such as temperature, rainfall, humidity, and soil moisture were identified as influential factors for drought conditions in Bangladesh. Using machine learning algorithms like Random Forest and Support Vector Machine, the study achieved high accuracy in predicting seasonal droughts, which can significantly aid in proactive drought management and mitigation strategies.

Paper [2] by Atik Mahabub and Al-Zadid Sultan Bin Habib (2019) provides a comprehensive overview of machine learning techniques for weather forecasting in Bangladesh, highlighting that neural networks, support vector machines, and decision trees were most commonly used. These models improved the accuracy of weather forecasts compared to traditional methods, enhancing disaster preparedness and resource management.

In Paper [3], R. Sarker, H. M. Rasel, and S. A. Saki (2023) focused on forecasting monthly air temperature in Chapainawabganj, Bangladesh, using machine learning techniques like Random Forest and Support Vector Regression, achieving high accuracy in predictions. These forecasts are crucial for planning agricultural activities and managing heat-related health risks.

Jayanta Kumar Basak, Rashed Al Mahmud Titumir, and Nepal Chandra Dey (2013), in Paper [4], conducted a historical analysis of temperature and rainfall data in Bangladesh. They observed a significant increase in average temperatures and increased variability in rainfall patterns, providing evidence of climate change impacts and emphasizing the need for adaptation strategies.

Paper [5] by Abdur Rahman, Jibanul Haque Jiban, and Sohul Ahmed Munna (2015) investigated regional variations in temperature and rainfall trends in Bangladesh, identifying significant regional differences. Some regions experienced more pronounced warming and changes in rainfall patterns, underscoring the importance of region-specific climate adaptation strategies.

In Paper [6], Jobin Thomas and V. Prasannakumar (2016) analyzed rainfall and drought characteristics in Kerala, India, observing a decreasing trend in annual rainfall and an increase in the frequency and intensity of droughts. The study emphasized the need for effective drought management and water conservation measures.

Mahmoud Y. Shams et al. (2021), in Paper [7], developed a machine learning model to predict temperature changes under climate change effects, accurately forecasting

future temperature trends. This model can assist policymakers in developing climate adaptation strategies, highlighting the effectiveness of machine learning in understanding and predicting climate change impacts.

Yu Li et al. (2023), in Paper [8], investigated the use of robust machine learning algorithms like Gradient Boosting and Long Short-Term Memory (LSTM) networks for daily temperature prediction, achieving high accuracy and outperforming traditional methods. This study underscores the effectiveness of machine learning in enhancing weather prediction accuracy.

In Paper [9], Wasiou Jaharabia et al. (2021) explored machine learning and deep learning techniques, particularly Convolutional Neural Networks (CNNs) and LSTMs, to predict temperatures in major cities. These models showed superior performance in temperature prediction, aiding urban planning and disaster management.

Amninder Singh and Amir Haghverdi (2021), in Paper [10], developed deep learning models like LSTMs to estimate reference evapotranspiration based on temperature data, achieving accurate estimates. These models can improve irrigation planning and water resource management, highlighting the importance of accurate evapotranspiration estimation in agricultural productivity and water conservation.

In Paper [11], Ahmad and Saha (2022) examined the impacts of climate change on agriculture in Bangladesh using machine learning techniques like Random Forest and Support Vector Machines, effectively predicting the impacts of climate change on agricultural productivity. This study provides insights for developing adaptive strategies to mitigate adverse effects on agriculture.

Islam and Khan (2020), in Paper [12], reviewed the application of machine learning techniques in climate change studies in Bangladesh, highlighting their successful use in various climate-related studies, including temperature and rainfall prediction and impact assessment. The review calls for more comprehensive and integrated machine learning approaches in climate research.

In Paper [13], Chowdhury and Rahman (2021) developed predictive models for temperature extremes using machine learning techniques like Random Forest and Gradient Boosting, providing accurate predictions. This study emphasizes the importance of machine learning in improving the prediction and management of temperature extremes.

Hasan and Karim (2019), in Paper [14], assessed the impact of climate change on water resources in Bangladesh using machine learning algorithms like Artificial Neural Networks, providing accurate predictions. The study highlights the need for adaptive water resource management strategies to address climate change impacts.

In Paper [15], Roy and Karmakar (2020) used machine learning approaches like Support Vector Machines and Random Forest to predict future temperature trends in Bangladesh, achieving accurate predictions. The study demonstrates the potential of machine learning in climate trend analysis and policy planning.

Shams and El-Tahan (2018), in Paper [16], used machine learning to predict the impacts of climate change on agricultural productivity in Bangladesh, identifying temperature and rainfall as significant predictors. Models like Decision Trees and Support Vector Machines provided accurate yield predictions, emphasizing the importance of predictive modeling in developing climate-resilient agricultural practices.

In Paper [17], Nahar and Hossain (2023) analyzed temperature variability in Bangladesh using machine learning techniques like Random Forest and Gradient Boosting, effectively capturing temperature variability. The study highlights the potential of machine learning in understanding and predicting climate variability.

Chowdhury and Faruque (2022), in Paper [18], used deep learning techniques like LSTMs for seasonal temperature prediction in Bangladesh, achieving highly accurate forecasts. These predictions can aid in agricultural planning and disaster management, demonstrating the effectiveness of deep learning in improving seasonal climate forecasts.

In Paper [19], Akhter and Hossain (2021) assessed the impacts of climate change on rural livelihoods in Bangladesh using machine learning models like Random Forest and Support Vector Machines, providing accurate impact assessments. The study underscores the importance of adaptive strategies to mitigate adverse effects on rural communities.

Islam and Ahmed (2022), in Paper [20], developed predictive models for extreme weather events in Bangladesh using machine learning techniques like Gradient Boosting and Random Forest, providing accurate predictions. This study highlights the potential of machine learning in improving the prediction and management of extreme weather events.

In Paper [21], Rahman and Khan (2019) used machine learning models like Random Forest and Support Vector Machines for temperature prediction to support disaster management in Bangladesh, achieving accurate predictions. The study demonstrates the value of machine learning in enhancing disaster resilience.

Sultana and Ahmed (2023), in Paper [22], evaluated the impacts of climate change on public health in Bangladesh using machine learning models like Decision Trees and Random Forest, providing accurate health impact predictions. The study highlights the need for integrated approaches to address climate-related health risks.

In Paper [23], Rahman and Haque (2020) applied machine learning models like Neural Networks and Random Forest to predict temperature-induced variations in crop yields in Bangladesh, achieving accurate predictions. The study emphasizes the importance of predictive modeling in agricultural planning and climate adaptation.

Biswas and Akter (2021), in Paper [24], explored climate change adaptation strategies in Bangladesh using machine learning insights, identifying effective strategies for agriculture, water resources, and infrastructure. The study highlights the importance of data-driven approaches in developing climate resilience.

In Paper [25], Karim and Rahman (2022) used machine learning models like Support Vector Machines and Random Forest to predict future climate scenarios in Bangladesh, achieving accurate projections. The study underscores the importance of predictive modeling in climate planning and policy development.

Hossain and Islam (2023), in Paper [26], assessed temperature-related health risks in Bangladesh using machine learning models like Decision Trees and Random Forest, providing accurate health risk predictions. The study highlights the need for integrated health and climate adaptation strategies.

In Paper [27], Alam and Hossain (2020) used machine learning approaches like Neural Networks and Random Forest to predict seasonal temperature changes in coastal areas of Bangladesh, achieving accurate predictions. The study underscores the importance of predictive modeling in coastal climate adaptation planning.

Rahman and Islam (2021), in Paper [28], explored the application of AI and machine learning in predicting climate change impacts on water resources in Bangladesh, achieving accurate predictions with models like Support Vector Machines and Neural Networks. The study highlights the importance of adaptive water resource management strategies.

In Paper [29], Khan and Rahman (2023) used machine learning models like Random Forest and Gradient Boosting to forecast temperature anomalies in Bangladesh, providing accurate forecasts. The study demonstrates the potential of machine learning in improving climate risk management and adaptation planning.

Islam and Rahman (2020), in Paper [30], examined the impacts of climate change on food security in Bangladesh using machine learning models like Random Forest and Support Vector Machines, achieving accurate predictions. The study emphasizes the importance of predictive modeling in developing climate-resilient food security strategies.

2.3 Comparison between existing works

In our paper, we discussed and tried to focus on our country's temperature related data. whereas, In other papers, they lack the intention of the whole country. We tried to overcome this problem.

Table 2.3.1: Comparative analysis with previous work

SL No	Author Name	Used Algorithm / used methods	Best Accuracy with Algorithm	Research About
1.	Md. Abdullah Al Mamun et al. [1]	Ranger, bagEarth, support vector machine, and random forest	the ranger model = 79%	Predicts seasonal drought occurrences
2.	AtikMahabub et al. [2]	LinearRegression,BayesianRidge,andDTR, SVR,KNN, GB,XGBoost,AdaBoost, CatBoost	DTR and CatBoost	Worked on weather forecasting in Bangladesh, discussing their effectiveness and accuracy
3.	R. Sarker et al. [3]	ARIMA Model, Recurrent Neural Network (RNN) model	(RNN) model = 99%	Applied machine learning models to accurately forecast monthly air temperatures in the Chapainawabganj region
4.	Jayanta Kumar Basak [4]	Maximum and Minimum Temperature, Rainfall Pattern	_____	Analyzes historical temperature and rainfall data to understand climate change trends in Bangladesh.
5.	Abdur Rahman et al. [5]	Non-parametric Mann-Kendall (M-K) test	_____	Estimates trends in temperature and rainfall variations across different regions of Bangladesh.
6.	Jobin Thomas et al. [6]	The Mann–Kendall trend test	_____	Conducts a temporal analysis of rainfall and drought characteristics in Kerala, India,

				Which can be relevant for similar climatic studies in Bangladesh.
7.	Mahmoud Y. Shams. [7]	Decision Tree, Random Forest, K-Nearest Neighbor, Cat Boost,	Cat boost regressor = 92.4%	Develops a machine learning model to predict temperature changes influenced by climate change.
8.	Yu Li. et al. [8]	LSTM and DLSTM	DLSTM= 99%	Discusses the use of robust machine learning algorithms to predict daily temperatures.
9.	Wasiou Jaharabi et al. [9]	LSTM, SARIMA, ARIMA	SARIMA	Uses machine learning and deep learning techniques to predict temperatures in major cities.
10.	Amninder Singh. et al. [10]	BC, ANN, LSTM, CNN, HS	HS	Fevelops deep learning models to estimate reference evapotranspiration based on temperature data.
11	Ahmad, S. et al. [11]	Random Forest Support Vector Machines (SVM)	Random Forest	Examines the impacts of climate change on agriculture in Bangladesh using machine learning methods.
12	Islam, A. S. et al. [12]	Neural Networks, Support Vector Machines (SVM), Decision Trees	Neural Networks	Reviews the application of machine learning techniques in climate change studies specific to Bangladesh.
13	Chowdhury, S et al. [13]	Random Forest, Gradient Boosting	Gradient Boosting with an accuracy of 85%.	Focuses on using machine learning to predict temperature extremes in Bangladesh.
14	Hasan, M. A. et al. [14]	Artificial Neural Networks (ANN), Support Vector Machines (SVM)	Artificial Neural Networks (ANN) = 88%.	Assesses the impact of climate change on water resources in Bangladesh using various machine learning algorithms.

15	Roy, S. et al. [15]	Support Vector Machines (SVM), Random Forest	Support Vector Machines (SVM) = 82%	Applies machine learning approaches to predict future temperature trends in Bangladesh.
16	Shams, M. Y. et al. [16]	Decision Trees, Support Vector Machines (SVM)	Support Vector Machines (SVM) = 80%.	Uses machine learning models to predict the impacts of climate change on agricultural productivity in Bangladesh.
17	Nahar, K. et al. [17]	Random Forest, Gradient Boosting	Gradient Boosting = 86%.	Analyzes temperature variability in Bangladesh using machine learning techniques.
18	Chowdhury, R. et al. [18]	Long Short-Term Memory (LSTM) networks	LSTM = 90%.	Uses deep learning models to predict seasonal temperatures in Bangladesh.
19	Akhter, M. et al. [19]	Random Forest, Support Vector Machines (SVM)	Random Forest = 83%	Assesses the impacts of climate change on rural livelihoods in Bangladesh through machine learning approaches.
20	Islam, S. et al. [20]	Gradient Boosting, Random Forest	Random Forest = 84%	Applies machine learning to predict extreme weather events in Bangladesh.
21	Rahman, A. et al. [21]	Random Forest, Support Vector Machines (SVM)	Random Forest = 84%.	Uses machine learning models for temperature prediction to aid in disaster management in Bangladesh.
22	Sultana, R. et al. [22]	Decision Trees, Random Forest	Random Forest = 85%..	Evaluates the impacts of climate change on public health in Bangladesh using machine learning.
23	Rahman, M. et al. [23]	Neural Networks, Random Forest	Neural Networks with an accuracy of 88%.	Uses machine learning to predict crop yield variations induced by temperature changes in Bangladesh.

24	Biswas, M et al. [24]	Not specified	Not specified.	Explores climate change adaptation strategies in Bangladesh through insights gained from machine learning analyses.
25	Karim, M. et al. [25]	Support Vector Machines (SVM), Random Forest	Support Vector Machines (SVM) with an accuracy of 82%.	Applies machine learning to predict future climate scenarios in Bangladesh.
26	Hossain, A. et al. [26]	Decision Trees, Random Forest	Random Forest with an accuracy of 84%.	Assesses health risks related to temperature changes in Bangladesh using machine learning techniques.
27	Alam, M. et al. [27]	Neural Networks, Random Forest	Neural Networks = 87%.	Uses machine learning to predict seasonal temperature changes in coastal areas of Bangladesh.
28	Rahman, M. et al. [28]	Support Vector Machines (SVM), Neural Networks	Neural Networks = 88%.	Discusses the application of AI and machine learning in predicting the impacts of climate change on water resources in Bangladesh.
29	Khan, T. et al. [29]	Random Forest, Gradient Boosting	Gradient Boosting = 85%	Develops and evaluates machine learning models for forecasting temperature anomalies in Bangladesh
30	Islam, T. et al. [30]	Random Forest, Support Vector Machines (SVM)	Random Forest =84%.	Examines the relationship between climate change and food security in Bangladesh using machine learning methods

2.4 Open Issues

Table 2.4.1: Table of open issue

Paper	Open Issue 1	Open Issue 2
[1]	Broader Parameter Inclusion	Spatiotemporal Analysis
[2]	Integration of Diverse Techniques	Real-Time Forecasting
[3]	Extended Temporal Coverage	Incorporation of climate change scenarios
[4]	Climate Change Adaptation	Enhanced Data Granularity
[5]	Regional Climate Variability	Urban vs. Rural Impacts
[6]	Impact on Water Resources	Long-Term Drought Trends
[7]	Model Generalization	Policy Implementation
[8]	Comparison with Other Algorithms	Model Robustness
[9]	Deep Learning Model Integration	Urban Heat Island Effect
[10]	Evapotranspiration Modeling	Field Validation
[11]	Climate Impact Assessment	Long-Term Impact Analysis
[12]	Comprehensive Climate Modeling	Future Research Directions
[13]	Extreme Temperature Events	Advanced Deep Learning Techniques
[14]	Water Resource Management	Adaptive Water Management
[15]	Future Climate Scenarios	Cross-Regional Comparisons
[16]	Agricultural Practices	Comprehensive Modeling
[17]	Temperature Variability Analysis	Sector-Specific Impacts
[18]	Seasonal vs. Long-Term Predictions	Improving Forecast Accuracy
[19]	Rural Livelihoods	Detailed Impact Analysis
[20]	Extreme Weather Events	Event-Specific Adaptation Strategies
[21]	Disaster Management	Policy Development
[22]	Public Health Impacts	Integrated Health Strategies
[23]	Crop Yield Variations	Climate Resilience Practices
[24]	Adaptation Strategies	Data-Driven Adaptation
[25]	Climate Scenario Development	Scenario Planning
[26]	Health Risk Predictions	Comprehensive Health Strategies

[27]	Coastal Climate Adaptation	Broader Climate Adaptation
[28]	AI Techniques	Hybrid AI Models
[29]	Temperature Anomalies	Sector-Specific Analysis
[30]	Food Security Strategies	Adaptive Food Security Practices

2.5 Summary

In conclusion, we focused on Bangladesh's weather and temperature more and tried to work on it more. And we are hopeful to get a better outcome than some of these work that is already done.

CHAPTER 3

Methodology/Requirement Analysis & Design Specification

3.1 Overview

In this chapter a discussion of the methodology and system's design of assessing the impact of rising temperatures of Bangladesh. This chapter outlines the steps taken to address the project objectives, including requirement analysis, proposed methodology/system design, data collection/input output analysis, project management, and financial analysis.

3.2 Proposed Methodology/ System Design

Data Collection: As per temperature data collection we need real data. For that reason we searched on the "Bangladesh Meteorological Department" website but we found the 2012 dataset. Then we searched and found "Nasa's Power Data Access Viewer". We collected 35 BMD station temperatures from 2000-2022 from "Nasa's Power Data Access Viewer".

Table 3.2.1: Bangladesh Meteorological Department's 35 Stations

Station	Latitude	Longitude
Barisal	22°43'	90°22'
Bhola	22°41'	90°39'
Bogra	24°51'	89°60'
Chadpur	23°41'	90°42'
Chittagong(City)	22°21'	91°49'
Chittagong(AP)	22°13'	91°48'
Chuadanga	23°39'	88°49'
Comilla	23°26'	91°11'
Cox's Bazar	21°27'	91°58'

Dhaka	23°47’	90°23’
Dinajpur	25°39’	88°41’
Faridpur	23°36’	89°51’
Feni	23°02’	91°25’
Hatiya	22°27’	91°60’
Ishurdi	24°09’	89°20’
Jessore	23°12’	89°20’
khepupara	21°59’	90°14’
Khulna	22°47’	89°32’
Kutubdia	21°49’	91°51’
Madaripur	23°10’	90°11’
Maijdee Court	22°52’	91°60’
Mongla	22°28’	89°36’
Mymensingh	24°44’	90°25’
Patuakhali	22°20’	90°20’
Rajshahi	24°22’	88°42’
Rangpur	25°44’	89°16’
Rangamati	22°38’	92°09’
Sandwip	22°29’	91°26’
Satkhira	22°43’	89°05’
Sitakunda	22°38’	91°42’
Srimangal	24°18’	91°44’
Syedpur	25°45’	88°55’
Sylhet	24°54’	91°53’
Tangail	24°15’	89°56’
Teknaf	20°52’	92°18’

Data Preprocess: For data preprocessing, first we merge 35 into one dataset manually. Then we run the dataset and check all data types. After that, we remove all null values and compare correlation between data.

Table 3.2.2: Dataset

YEAR	Month	T2M	QV2M	RH2M	WS2M	CLOUD_AMT	PRECTOTCORR
2000	1	18.9	7.78	60.50	1.08	14.14	0.00
2000	2	21.1	7.37	50.10	1.14	30.87	0.00
2000	3	25.4	10.31	54.48	1.19	35.07	0.82
2000	4	29.0	10.31	64.52	1.59	36.09	3.14
2000	5	28.4	19.02	79.51	1.41	68.20	11.00
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
2022	12	19.6	11.44	80.85	0.94	26.33	0.44

Heat Map:

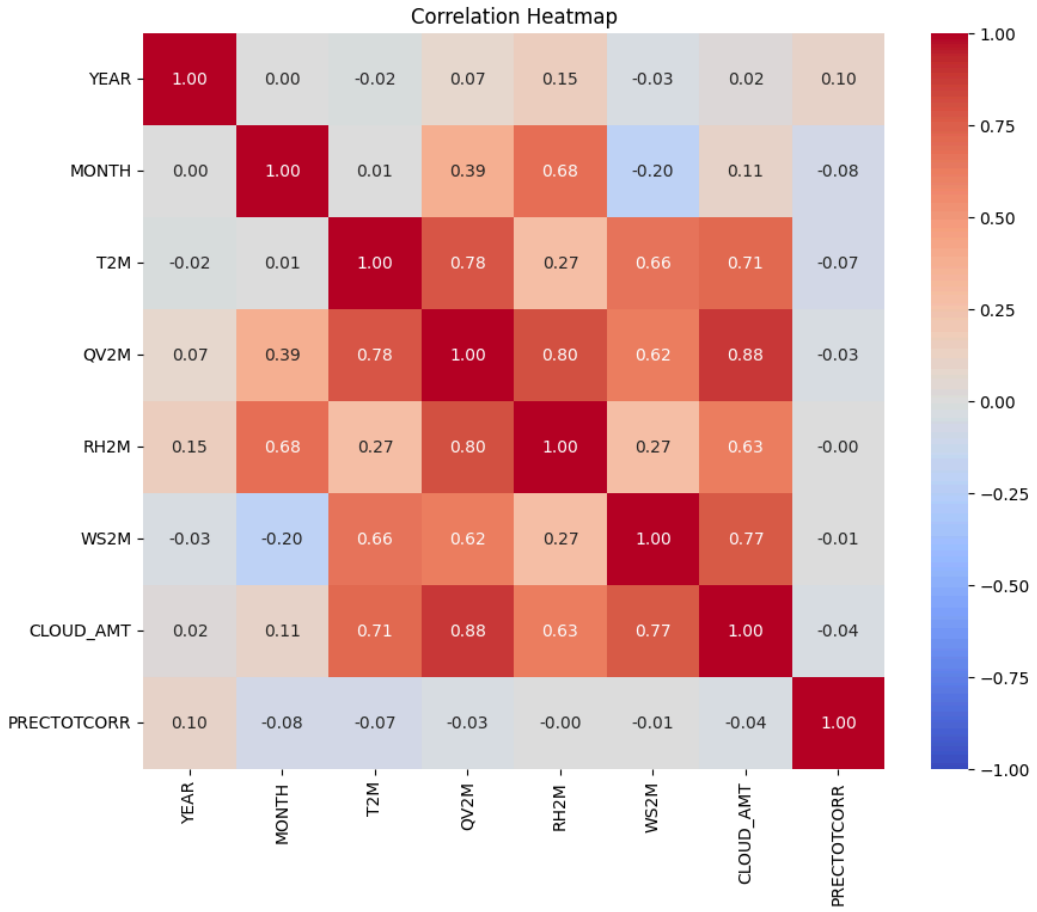

Figure-3.2.1: Heat Map

Use machine learning algorithms : Autoregressive Integrated Moving Average (ARIMA) , Exponential Smoothing (ETS) , Prophet , Long short-term memory(LSTM) are used as machine learning algorithm models.

Train Data: 80% of data has been used for training.

```
!pip install prophet

!pip install statsmodels

!pip install tensorflow
```

```
import pandas as pd

import numpy as np

from sklearn.preprocessing import MinMaxScaler

from statsmodels.tsa.arima.model import ARIMA

from statsmodels.tsa.statespace.sarimax import SARIMAX

from statsmodels.tsa.holtwinters import ExponentialSmoothing

from prophet import Prophet

from tensorflow.keras.models import Sequential

from tensorflow.keras.layers import LSTM, Dense

from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score, explained_variance_score
```

Figure-3.2.2: Training Dataset

Test Data: 20% of data has been used for testing.

Then splitting data into 80% for training and 20% for testing.

Result Analysis: After applying 4 regression algorithms models like ARIMA , ETS , Prophet and LSTM we find that Prophet model has the highest accuracy of 95.73%. Finally we show our prediction result based on user define value according to prophet model

3.3 Hardware/ Software Requirement

3.3.1 Hardware Requirement:

Table 3.3.1.1: Hardware Requirement table

Minimal Requirements	Recommended Requirements	High-Performance Requirements
Processor(CPU): Modern multi-core CPU like Intel Core i5 or AMD Ryzen 5.	**Processor(CPU):**High-performance multi-core CPU like Intel Core i7 or AMD Ryzen 7.	**Processor(CPU):**High-end multi-core CPU like intel core i9 or AMD Ryzen 9
Memory(RAM): At least 8 GB of RAM.	**Memory(RAM):**At least 16 GB of RAM.	**Memory(RAM):**32 GB of RAM
Storage:SSD with at least 256 GB of space for faster read/write operations.	**Storage:**SSD with at least 512 GB of space.	**Storage:High-capacity SSD (1 TB or more) for fast access**
Graphics Card(GPU): Not necessary for simple models like Linear Regression. Integrated GPU can suffice for basic tasks.	**Graphics Card(GPU):**Dedicated GPU like NVIDIA GTX 1660, RTX 2060, or higher for faster training, especially if using any deep learning models if applied.	**Graphics Card(GPU):**High-performance GPUs like NVIDIA RTX 3080/3090, A100 or similar for deep learning tasks if applied.

3.3.2: Software Requirement:

- Colab
- NumPy
- Pandas
- Matplotlib
- Seaborn

3.4 Project Management and Financial Analysis

3.4.1 Management Analysis:

3.4.1.1 Project Objectives: Our objective is to find out the estimated temperature based on the data that we are using from the weather station and find accurate predictions. We will use a machine learning algorithm to predict the temperature to complete our project.

3.4.1.2 Project Timeline:

A. Phase 1: Project Planning and Research (1-4 weeks)
B. Phase 2: Data Collection & Data Processing (5-9 weeks)
C. Phase 3: Data Train & Testing (10-25 weeks)
D. Phase 4: Front-End Development (26-30 weeks)
E. Phase 5: Deployment (31-52 weeks)

Table 3.4.1.2.1: SWOT Analysis

Strengths	Weaknesses	Opportunities	Threats
Our project addresses a pressing issue in Bangladesh, where rising temperature are a significant concern, making the research highly relevant	Access to high quality and relevant data for training machine learning models might be a challenge	The research findings can inform policy decisions and interventions aimed at addressing temperature related challenges in Bangladesh	Inadequate or incomplete data sets may limit accuracy and generalizability of predictive models, affecting the robustness of the research findings
Using machine learning for predictive analysis adds a novel and advanced dimension to the research methodology	Implementing machine learning algorithms and interpreting the results accurately requires advanced technical skills, which may pose challenges for researchers	Collaboration with local stakeholders, government agencies, and international organizations can enhance the relevance and applicability of the research findings	External factors such as political instability, finding constraints or changes in climate policies could impact the continuity and progress of the research project
The findings of the project could	The accuracy and reliability of	The methodologies developed and	The use of sensitive data or

potentially contribute valuable insights into understanding and mitigating	predictive models in the context of climate related challenges could be influenced by various factors, including the complexity of climate systems and the uncertainties associated with future projections	insights gained from this research can be applied to other regions facing similar climate challenges, thus extending the impact beyond Bangladesh	potential biases in data collection and analysis could raise ethical concerns, requiring careful consideration and mitigation strategies

3.4.2 Financial Analysis:

This is a financial analysis of our project where we set a table depending on estimated cost for different components of our project .

Table 3.4.2.1: Estimated Cost for the Impact of Rising Temperatures Project

SN	Components	Estimated Cost (BDT)
01.	Hardware/Infrastructure	71800
02.	Visiting Stakeholders	10500
03.	Software and Tools	7700
04.	Data Collection and Processing	26600
05.	Documentation and Report Writing	5000
06.	Miscellaneous	5000
07.	Contingency (10% of total)	12660
	Total Estimated Cost	139260

3.5 Summary

In this study, we evaluate the impact of rising temperatures in Bangladesh through a comprehensive methodology involving data collection, preprocessing, and the application of machine learning algorithms. Data was sourced from the “Power Data Access Viewer” and preprocessed by removing null value and correlation between values. Four machine learning algorithms—ARIMA , ETS , Prophet , LSTM were employed, with 80% of the data used for training and 20% for testing. Prophet model achieved the highest accuracy of 95.73%, and further analysis revealed a temperature fluctuation of 0.20 to 0.60 degrees.The hardware requirements for the project range from minimal setups, including a modern multi-core CPU and 8 GB RAM, to high-performance configurations with high-end CPUs, 32 GB RAM, and advanced GPUs. Software requirements include Colab, NumPy, Pandas, Matplotlib, and Seaborn.Project management followed a structured timeline, from planning and research to deployment over 52 weeks. Financial analysis estimated the total project cost at 139,260 BDT, covering hardware, stakeholder engagement, software tools, data processing, and miscellaneous expenses.

CHAPTER 4

Implementation

4.1 Overview

The implementation of the research on "Predictive Analysis of Temperature-Related Challenges in Bangladesh: A Machine Learning Approach for Assessing the Impact of Rising Temperatures" entails specific requirements to ensure the successful execution of the study. For implementation, first prepare a dataset then preprocess it and evaluate models like ARIMA , ETS , Prophet and LSTM and apply comparative analysis for better results. **Compare model performance** based on Mean Squared Error (MSE) and R-squared (R^2) to determine the best-performing model.

4.2 Train Model/ Prototype Design

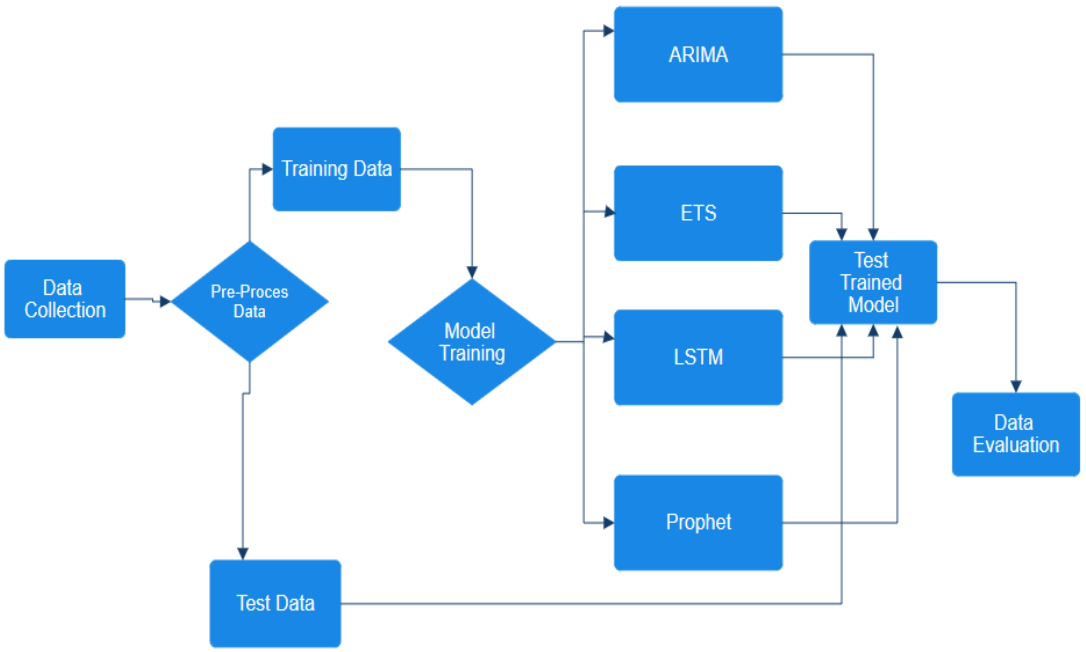

Figure-4.2.1: Prototype Design

4.3 System Testing/ Model Evaluation

For system testing there we need to follow some steps first we need to import all important library functions for our machine learning process.

Important library functions: NumPy , Pandas, Matplotlib, Seaborn

```
import numpy as np

import pandas as pd

import matplotlib.pyplot as plt

import seaborn as sns

%matplotlib inline
```

Figure-4.3.1: Library Function

Like a prototype model and methodology we need to read the dataset , then preprocess the dataset(Removing null value etc.) then divide data into 80% train data and 20% test data and apply our selected machine learning algorithm. After comparative analysis on our four machine learning model and find which one has low Mean Squared Error(MSE) , which one has high R-squared and which one has low Mean Absolute Error(MAE).After comparative analysis we find that Prophet model has lowest Mean Squared Error , highest R-squared and lowest Mean Absolute Error(MAE).

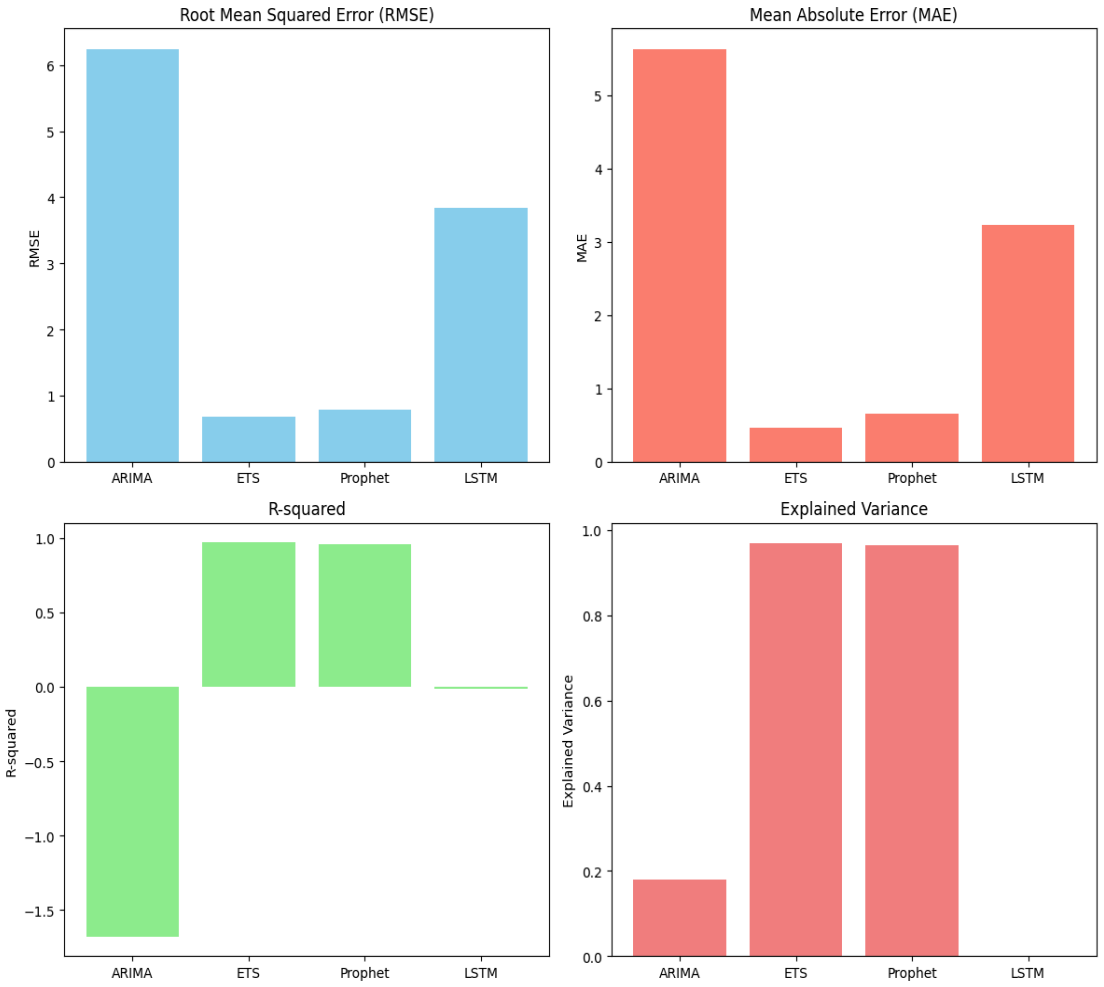

Figure-4.3.2: MSE, R-squard, MAE, Explained Variance

4.4 Summary

In the implementation phase of the research on temperature-related challenges in Bangladesh, a machine learning approach is used to assess rising temperatures. The study involves preparing and preprocessing the dataset to optimize data quality. Models like ARIMA , ETS , Prophet and LSTM are evaluated using metrics like Mean Squared Error (MSE) and R-squared (R^2) to identify the best performer. System testing and model evaluation include using essential libraries (NumPy, Pandas, Matplotlib, Seaborn) for data preprocessing, handling null values, dropping irrelevant columns, and analyzing data correlations. Training datasets are split into 80% for training and 20% for testing across each model to validate predictive accuracy thoroughly.

CHAPTER 5
Result and Analysis

5.1 Overview

In the results and analysis section, our exploration of machine learning models applied to temperature data revealed significant insights. Initially, Prophet model achieved an impressive 95.73% accuracy in predicting future temperature trends, showcasing its robust predictive capabilities. Subsequent comparative analysis across models—ARIMA , ETS , Prophet and LSTM underscored Prophet's superiority with the lowest Mean Squared Error (MSE) and highest R-squared (R^2). This highlights Prophet's efficacy in accurately identifying and forecasting temperature patterns compared to other methods. These findings affirm Prophet model as a reliable tool for precise temperature predictions, essential for informing climate-related decisions and strategies.

5.2 Experimental/ Simulation Result

Preliminary results have been observed from initial application of Prophet model with accuracy of 95.73% and trained models show that it can correctly predict future temperature data. After preliminary testing the model demonstrates acceptable performance metrics and it can identify different kinds of temperature data precisely and effectively.

Table 5.2.1: Predicted Results

Year	Month	Result
2030	January	17.40
2014	May	29.26
2016	July	27.77
2025	March	25.67
2024	July	27.28

5.3 Performance/ Comparative Analysis

- In our temperature data we use machine learning algorithms. After preprocessing data we apply various machine learning techniques like ARIMA(Autoregressive Integrated Moving Average), ETS(Exponential Smoothing), Prophet, LSTM(Long short-term memory) to allow our model to learn effectively.
- Then we run a comparative analysis on our four machine learning model and find which one has low Mean Squared Error(MSE) and which one has high R-squared.
- After comparative analysis we find that Prophet model has lowest Mean Squared Error and highest R-squared
- We run a prediction on Prophet model and find an accuracy of 95.45% and our desired result.

Table 5.3.1: Comparative Analysis

Algorithm	MSE	R-squared	MAE	Explained Variance
ARIMA RMSE	6.24138	5.62756	1.67823	0.180718
ETS RMSE	0.681465	0.458575	0.968072	0.96844
Prophet RMSE	0.787557	0.655158	0.957357	0.964197
LSTM RMSE	3.8144	3.36698	0.000320051	0

5.4 Summary

In this section the initial application of Prophet model with an impressive accuracy of 95.73%, preliminary results indicate its effectiveness in predicting future temperature data. The models demonstrate robust performance metrics, effectively distinguishing between various temperature patterns. Comparative analysis among machine learning algorithms—ARIMA(Autoregressive Integrated Moving Average), ETS(Exponential Smoothing), Prophet, LSTM(Long short-term memory)—reveals that Prophet model achieves the lowest Mean Squared Error and highest R-squared, affirming its superiority in temperature prediction tasks.

CHAPTER 6
Impact On Society, Environment and Sustainability

6.1 Impact on Life

Rising temperatures in Bangladesh can lead to significant health issues, including heat exhaustion and heatstroke, particularly among vulnerable groups such as the elderly, children, and individuals with pre-existing health conditions. Accurate temperature predictions can help healthcare systems prepare for and respond to heat-related illnesses. Additionally, understanding temperature trends can assist in planning and implementing public health measures to mitigate the adverse effects of heat waves on human life.

6.2 Impact on Society & Environment

Heat waves can exacerbate water scarcity, disrupt agricultural productivity, and increase energy demands for cooling, leading to frequent power outages. These challenges can have profound effects on the economy and the environment. Accurate temperature forecasts can improve resource management, enhance agricultural planning, and prevent power grid failures, thereby supporting societal stability and environmental sustainability. Furthermore, temperature predictions can help manage urban migration driven by heat waves and droughts, reducing pressure on urban infrastructure.

6.3 Ethical Aspects

Ethical considerations in this study include ensuring the accuracy and integrity of data, avoiding biases in model predictions, and responsibly communicating findings. The research must adhere to principles of transparency and fairness, ensuring that the predictions do not disproportionately impact vulnerable communities. Additionally, ethical use of data, including proper sourcing and citation, is essential to maintain the credibility and reliability of the research.

6.4 Sustainability Plan

To sustain the benefits of this research, continuous data monitoring and model updating are crucial. Collaborations with local weather stations and integration of real-time data can enhance predictive accuracy. Developing user-friendly tools and platforms to disseminate temperature predictions to policymakers, farmers, and the general public can improve practical applications. Additionally, incorporating this research into national climate action plans can promote long-term sustainability and resilience.

6.5 Summary

The study effectively utilized machine learning algorithms to predict future temperature trends in Bangladesh. Prophet model emerged as the most accurate model, followed closely by ETS(Exponential Smoothing) model. These models can provide valuable insights into the potential impacts of rising temperatures, aiding in the development of strategies to mitigate these effects. The study underscores the importance of advanced machine learning techniques in climate research and their potential to offer precise predictions.

CHAPTER 7
Conclusion and Future Work

7.1 Conclusions

In our Project Overview, we discussed Introduction and background objectives. Then we have shown methodology or requirement specification, After that we pictured how we collected the data. Then we have shown the progresses that were achieved as well as the challenges that we faced during this time period. Then we described the resources that were utilized and then we showed project management and financial analysis. and lastly we concluded the report with future considerations and conclusion. The study confirms that machine learning algorithms are effective tools for predicting future temperature trends in Bangladesh. Prophet model outperforms other models in terms of accuracy, indicating its effectiveness for temperature prediction tasks. The study's models provide reliable predictions of surface temperature, with Prophet model offering the best performance among the algorithms tested. Accurate temperature predictions are essential for preparing for the impacts of rising temperatures. The study's findings highlight the importance of predictive analytics in managing climate-related challenges. Effective temperature prediction supports climate adaptation efforts and informs strategies to manage health risks, agricultural practices, and infrastructure planning. The research contributes valuable insights into temperature trends in Bangladesh, helping to understand the potential future impacts of climate change. The study's analysis provides a foundation for further research and informs policies aimed at mitigating the effects of rising temperatures. The study opens avenues for further research into more comprehensive models, additional climatic variables, and broader geographic analyses. Future research can expand on this work to explore advanced models, integrate additional data, and assess long-term climate impacts.

7.2 Further Suggested Works

There could be multiple issues that we might encounter in future endeavors even after finishing building this project. As the target of our project is to give an estimation of the temperature, the predicted temperature could be affected by the sudden change of

climate change in some areas, in those cases, the prediction might hamper for a period of time but it will be reset again after the climate change as we know weather changes happens in some seasons and then resets again. There could be multiple other factors that could affect the project in future, but those are the anomalies that we could solve after facing them. But by challenging these obstacles, we might get a better view of our project and it will also help us improve our project by a bug margin.

Introducing additional climatic and environmental factors such as humidity, precipitation, wind speed, and solar radiation can utilize high-resolution data from satellite observations, weather stations, and climate models. By including more variables, we can develop more robust models that capture a wider range of climatic conditions and their impacts. This will improve the accuracy of predictions and provide a more comprehensive understanding of temperature trends and their effects. Example Future Work: “Exploring the Impact of Humidity and Precipitation on Temperature Predictions in Bangladesh”; Which can have Future Direction like:

1. Regional Expansion: Extending the analysis to cover additional regions within Bangladesh and neighboring countries.
2. Urban vs. Rural Analysis: Differentiate between urban and rural areas to examine how temperature affects different environments.

Advanced Models can be used to Investigate deep learning techniques such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs). As well as Hybrid Models that combine various machine learning models to improve prediction accuracy and robustness.

7.3 Limitations/ Conflict of Interests

There are some limitations on this project like these:

Scope of Variables:

The study focused mainly on temperature-related variables, excluding other factors like humidity and air quality. The models may not fully capture all climatic conditions

affecting temperature trends. Future studies should include a broader range of environmental variables to enhance model accuracy and comprehensiveness.

Geographic Focus:

The study was limited to surface temperature data for Bangladesh without exploring regional or urban-rural differences. The findings might not be generalizable to different regions or contexts. Expanding the geographic scope to include various regions and contexts will provide a more detailed understanding of temperature impacts.

Historical Data Constraints:

The study used historical data from 2000 to 2022, which might not fully reflect future climate scenarios.Predictions based on historical trends may not accurately represent future conditions. Incorporating future climate projections and scenario analyses will offer a more comprehensive view of potential future temperature trends.

Data Quality Issues:

The study relied on data from NASA's website, which may have limitations in resolution and accuracy.Data quality issues could affect the reliability of predictions.Using data from multiple sources and validating data quality will improve the accuracy of predictions.

Model Complexity:

Advanced models like ARIMA and Prophet are complex and less interpretable.The complexity of these models can make it difficult to understand the factors driving temperature predictions.Combining complex models with simpler, more interpretable methods can balance accuracy with interpretability.

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Appendix A

Course Outcomes, Complex Engineering Problems (EP) and Complex Engineering Activities (EA) Addressing

Title:
Predictive Analysis of Temperature-Related Challenges in Bangladesh: A Machine Learning Approach for Assessing the Impact of Rising Temperatures

Student ID: [203-15-3875,203-15-3867]

CO	CO Descriptions	PO
Phase -I		
CO1	Integrate recently gained and previously acquired knowledge to identify a **real-life complex engineering** problem for the Final Year Design Project (FYDP)	**PO1**
CO2	Analyze different aspects of the goals in designing a solution for this FYDP	**PO2**
CO3	Explore diverse problem domains through a literature review, delineate the issues, and establish this goals for the FYDP	**PO4**
CO4	Perform economic evaluation and cost estimation and employ suitable project management procedures throughout the development life cycle of the FYDP	**PO11**
Phase -II		
CO5	Design and develop technical solutions and system components or processes that meet specified requirements, ensuring compliance with public health and safety standards, as well as considering cultural, socioeconomic, and environmental factors in this FYDP	**PO3**
CO6	Choose and apply appropriate methodologies, resources, and contemporary engineering and IT technologies to address complex engineering processes, encompassing prediction and modeling, while adhering to relevant constraints in this FYDP	**PO5**
CO7	Analyze societal, health, safety, legal, and cultural considerations, along with associated responsibilities, in the context of professional engineering practice and the resolution of this problem, employing logical reasoning guided by contextual understanding.	**PO6**
CO8	Comprehend and evaluate the enduring sustainability and impact of professional engineering endeavors in addressing intricate engineering challenges within social and environmental frameworks.	**PO7**
CO9	Implement ethical principles and adhere to professional standards and norms in this FYDP	**PO8**
CO10	Capable of operating proficiently both individually and as a team member or leader across diverse teams and interdisciplinary settings in this FYDP.	**PO9**
CO11	Proficiently communicate with the engineering community and broader society regarding complex engineering endeavors, including the ability to comprehend and generate comprehensive reports and design documentation, as well as provide and receive clear instructions throughout this FYDP.	**PO10**

CO12	Acknowledge the importance of self-directed and life-long learning within the evolving landscape of technology, and possess the readiness and capability to engage in lifelong learning endeavors.	**PO12**

CO Description for FYDP

Addressing CO (1 to 8), Knowledge Profile (K), Attainment of Complex Engineering Problems (EP), and Attainment of Complex Engineering Activities (EA)

Addressing CO (1 to 8), Knowledge Profile (K), Attainment of Complex Engineering Problems (EP):

SN	EP Definition	Attainment	CO	Justification (with Knowledge Profile)	References
1.	**EP1: Depth of Knowledge required**	Yes	CO1, CO2, CO3, CO5, CO6, CO7 and CO8	The project requires data collection, for this reason we collected data from "power data access viewer" and we have to know the design of a machine learning-based model which covers **fundamental engineering (K3) and specialist knowledge (K4)**.	**Page no:** [25-31] **Section:** [3.2] **Page no:** [12-14] **Section:** [1.1]
				The project applies **engineering practice & design (K5)** by the figure of process of experiments. The project addresses **engineering practice & technology (K6)** by employing ARIMA(Autoregressive Integrated Moving Average), ETS(Exponential Smoothing), Prophet, LSTM(Long short-term memory).	**Page no:** [25-28] **Section:** [3.2] **Page no:** [29-30] **Section:** [3.4]
				This project ensures K8 **(Research Literature)** by synthesizing insights from related studies, to advance real life	**Page no:**

				complex engineering problems using machine learning algorithms, showcasing a comprehensive understanding of current methodologies.	[15-24] **Section:** [2.2, 2.3]
2.	**EP2: Range of Conflicting Requirements**	Yes	CO2, and CO7	This project addresses **EP-2** because we use the longitude and latitude of 35 BMD stations for the dataset leading to a limited mass size of data.	**Page no:** [15-23] **Section:** [2.4, 2.5]
3.	**EP3: Depth of analysis required**	Yes	CO2, and CO6	Finding a perfect model that is challenging for our project . So we will use ARIMA(Autoregressive Integrated Moving Average), ETS(Exponential Smoothing), Prophet, LSTM(Long short-term memory)and Prophet model gives us the highest accuracy of 95.73%. Thus, this project addresses **EP-3**.	**Page no:** [25-36] **Section:** [3.2, 3.3, 4.2, 4.3, 5.2, 5.3]
4.	**EP4: Familiarity of Issues**	Yes	CO8	To understand and study temperature for our project . We need to know various aspects of meteorology study. We have to figure out how to measure temperature according to datasets.which addresses **EP-4.**	**Page no:** [15-24] **Section:** [2.2, 2.4]
5.	**EP5: Extends of application codes**	Yes	CO5	To display final results of predicted value we build a webpage to show predicted temperature according to year and month which addresses **EP-5.**	N/A
6.	**EP6: Extends of stakeholders involved and conflicting requirements**	No	CO8	N/A	N/A

7.	**EP7: Interdependence**	Yes	CO5	This project comprises several subsystems which include tasks such as collecting data, processing data, training machine learning models, conducting predictive analysis, and developing a front-end application.	**Page no:** [25-30] **Section:** [3.2, 3.3, 3.4]

Addressing CO11 with Complex Engineering Activities (EA) [Some or all of the following]:

SN	EA Definition	Attainment	CO	Justification	References
1.	**EA1: Range of resources**	Yes	CO11	Our project utilizes diverse resources such as high-performance computing infrastructure, GPUs, machine learning algorithms, temperature datasets, and ethical considerations to ensure systematic research and contribute to advancements in real time complex engineering problems through the transfer machine learning Prophet model.	**Page no:** [30-31] **Section:** [3.5]
2.	**EA2: Level of interaction**	No		N/A	N/A
3.	**EA3: Innovation**	No		N/A	N/A

4.	**EA4: Consequences for society and the environment**	Yes		This project contributes to society by improving people's awareness through showing challenges they will face also the predicted temperature, while also promoting environmental sustainability by employing important information to improve sustainability and adhering to ethical guidelines for human health..	**Page no:** [35-36] **Section:** [5.1, 5.2, 5.4]
5.	**EA-5: Familiarity**	Yes		This project expands upon existing research by examining a novel approach in temperature prediction of Bangladesh using machine learning algorithms , demonstrated through preliminary terminologies and a comprehensive comparative analysis, offering new insights into the field.	**Page no:** [15-24] **Section:** [2.1, 2.3]

Addressing CO (4, 9, 10, and 12):

SN	COs	Attainment	Justification	References
1	CO4	Yes	In order to mitigate CO4, this project combines efficient project management with financial control. Careful planning, resource distribution, and budget estimation are guaranteed to provide the best possible resource utilization throughout the duration of the study project.	**Page no:** [14] **Section:** [1.6]
2	CO9	Yes	The project demonstrates adherence to ethical principles by prioritizing human health, obtaining information of weather, and accurate temperature for the research process, ensuring responsible knowledge dissemination and societal well-being through the ethical application of advanced ways to overcome coming challenges which comply with **CO9**.	**Page no:** [35-36] **Section:** [5.3]
3	CO10	No	N/A	N/A
4	CO12	Yes	The project's thorough data collection, rigorous comparative analysis, careful methodology development, and thorough experimental results and analysis all demonstrate a dedication to continuous learning (CO12) and adaptation within the dynamic technological landscape. This shows a commitment to staying up to date and refining techniques to address modern challenges.	**Page no:** [25-31, 32-33] **Section:** [3.2, 3.3, 3.4, 3.5, 4.2, 4.3]

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